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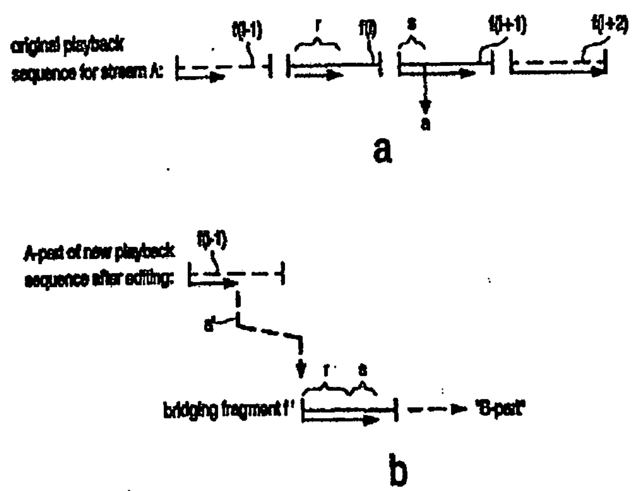

(57) Abstract

Various measures are proposed for enabling simultaneous reading and writing of real time information, such as a digital video signal, from/onto a disc-like record carrier. The measures embody a requirement to the size of the blocks of information recorded in fixed sized fragment areas on the record carrier, and may require a re-ordering of read steps in a read/write cycle. Further, measures are disclosed to enable reproduction and seamless editing. The seamless editing method requires the generation of one or more bridging blocks to be recorded in fixed size fragment areas on the disk like record carrier.

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Recording/reproduction and/or editing of real time information on/from a disc like record carrier.

The invention relates to an apparatus for recording a real time information signal, such as a digital video signal, on a disc like record carrier, to an apparatus for editing an information signal recorded earlier on said disc like record carrier, to corresponding methods for recording/editing information, to a reading apparatus for reading the information signal and to a record carrier. The record carrier may be of the magnetic or the optical type. An apparatus for recording a real time information signal, such as an MPEG encoded video information signal, on a record carrier is known from USP 5,579,183 (PHN 14818). The record carrier in the said document is in longitudinal form.

Disc like record carriers have the advantage of a short access time. This enables the possibility of carrying out "simultaneous" recording and reproduction of information signals on/from the record carrier. During recording and reproduction, information should be recorded on/reproduced from the record carrier such that an real time information signal can be recorded on the record carrier and "at the same time" a real time information signal recorded earlier on the record carrier can be reproduced without any interruption.

The invention aims at providing measures to enable the various requirements, such as the ones described above. In accordance with the invention, the apparatus for recording a real time information signal, such as a digital video signal, on a disc like record carrier, a data recording portion of which is subdivided into fixed sized fragment areas, the apparatus comprising

- input means for receiving the information signal,
- signal processing means for processing the information signal into a channel signal for recording the channel signal on the disc like record carrier,
- writing means for writing the channel signal on the record carrier,

the signal processing means being adapted to convert the information signal into blocks of information of the channel signal, the writing being adapted to write a block of information of

the channel signal in a fragment area on the record carrier, and wherein the signal processing is further adapted to convert the information signal into the blocks of information of the channel signal, such that the size of the blocks of information can be variable and satisfies the following relationship:

$$SFA/2 \leq \text{size of a block of the channel signal} \leq SFA,$$

where SFA equals the fixed size of the fragment area.

Further, the apparatus for editing a real time information signal, such as a digital video signal, recorded in an earlier recording step on a disc like record carrier, a data recording portion of which is subdivided into fixed sized fragment areas, the information signal being converted into a channel signal prior to recording and subsequently recorded on the record carrier, such that blocks of information of the channel signal are recorded in corresponding fragment areas on the record carrier, the apparatus comprising:

- input means for receiving an exit position in a first information signal recorded on the record carrier and for receiving an entry position in a second information signal, which may be the first information signal, recorded on the record carrier,
- means for storing information relating to the said exit and entry position,
- bridging block generating means for generating at least one bridging block of information, which bridging block of information comprises information from at least one of the first and second information signals, which information is located before the exit position in the first information signal and/or after the entry position in the second information signal, and where the size of a bridging block of information can be variable and satisfies the requirement:

$$SFA/2 \leq \text{size of a bridging block of information} \leq SFA,$$

where SFA equals the fixed size of the fragment areas,

- writing means for writing the at least one bridging block of information into a corresponding fragment area, and
- means for reproducing the edited stream of information from said record carrier.

Further, the apparatus for simultaneously recording and reproducing real time information signals, such as digital video signals, on/from a disc like record carrier, a data recording portion of which is subdivided into fixed sized fragment areas, the apparatus comprising

- input means for receiving a first information signal for recording,

- signal processing means for processing the first information signal into a channel signal for recording the channel signal on the disc like record carrier,
- writing means for writing the channel signal on the record carrier,

the signal processing means being adapted to convert the first information signal into blocks of information of the channel, the writing means being adapted to write a block of information of the channel signal in a fragment area on the record carrier,

the apparatus further comprising:

- reading means for reading blocks of information from corresponding fragment areas on the record carrier,
- signal processing means for processing the blocks of information so as to obtain a second information signal,
- output means for supplying the second information signal reproduced from the record carrier,

the simultaneous recording/reproduction of the first and second information signals being carried out in subsequent cycles, a cycle comprising a write step for writing a signal block of the first information signal into a fragment area on the record carrier and a plurality of read steps for reading a portion of information of the second information signal from the same plurality of fragment areas,

the apparatus being adapted to order the reading of the portions in a cycle.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments hereafter in the figure description, in which

figure 1 shows an embodiment of the apparatus,

figure 2 shows the recording of blocks of information in fragment areas on the record carrier,

figure 3 shows the principle of playback of a video information signal,

figure 4 shows the principle of editing of video information signals,

figure 5 shows the principle of "simultaneous" play back and recording,

figure 6 shows a situation during editing when the generation and recording of a bridging block of information is not required,

figure 7 shows an example of the editing of a video information signal and the generation of a bridging block of information, at the location of an exit point from the information signal,

figure 8 shows another example of the editing of a video information signal and the generation of a bridging block of information, at the same location of the exit point as in figure 7,

figure 9 shows an example of the editing of a video information signal and the generation of a bridging block of information, at the location of an entry point to the information signal,

figure 10 shows an example of the editing of two information signals and the generation of a bridging block of information,

figure 11 shows an example of the editing of two information signals and the generation of a bridging block of information, where the editing includes re-encoding some of the information of the two information signals,

figure 12 shows a further elaboration of the apparatus, and

figure 13 shows two examples of a re-ordering of read steps in one cycle in which information is written and "simultaneously" read on/from the record carrier.

Figure 1 shows an embodiment of the apparatus in accordance with the invention. The following figure description, the attention will be focused on the recording, reproduction and editing of a video information signal. It should however be noted that other types of signal could equally well be processed, such as audio signals, or data signals.

The apparatus comprises an input terminal 1 for receiving a video information signal to be recorded on the disc like record carrier 3. Further, the apparatus comprises an output terminal 2 for supplying a video information signal reproduced from the record carrier 3. The record carrier 3 is a disc like record carrier of the magnetic or optical form.

The data area of the disc like record carrier 3 consists of a contiguous range of physical sectors, having corresponding sector addresses. This address space is divided into fragment areas. A fragment area is a contiguous sequence of sectors, with a fixed length. Preferably, this length corresponds to an integer number of ECC-blocks included in the video information signal to be recorded.

The apparatus shown in figure 1 is shown decomposited into two major system parts, namely the disc subsystem 6 and the what is called "video recorder subsystem"8. The two subsystems are characterized by the following features:

- The disc subsystem can be addressed transparently in terms of logical addresses. It handles defect management (involving the mapping of logical addresses onto physical addresses) autonomously.
- For real-time data, the disc subsystem is addressed on a fragment-related basis. For data addressed in this manner the disc subsystem can guarantee a maximum sustainable bitrate for reading and/or writing. In the case of simultaneous reading and writing, the disc subsystem handles the read/write scheduling and the associated buffering of stream data from the independent read and write channels.
- For non-real-time data, the disc subsystem may be addressed on a sector basis. For data addressed in this manner the disc subsystem cannot guarantee any sustainable bitrate for reading or writing.
- The video recorder subsystem takes care of the video application, as well as file system management. Hence, the disc subsystem does not interpret any of the data that is recorded in the data area of the disc.

In order to realize real time reproduction in all situations, the fragment areas introduced earlier need to have a specific size. Also in a situation where simultaneous recording and reproduction takes place, reproduction should be uninterrupted. In the present example, the fragment size is chosen to satisfy the following requirement:

$$\text{fragment size} = 4\ \text{MB} = 2^{22}\ \text{bytes}$$

Recording of a video information signal will briefly be discussed hereafter, with reference to figure 2. In the video recorder subsystem, the video information signal, which is a real time signal, is converted into a real time file, as shown in figure 2a. A real-time file consists of a sequence of signal blocks of information recorded in corresponding fragment areas. There is no constraint on the location of the fragment areas on the disc and, hence, any two consecutive fragment areas comprising portions of information of the information signal recorded may be anywhere in the logical address space, as shown in figure 2b. Within each fragment area, real-time data is allocated contiguously. Each real-time file represents a single AV stream. The data of the AV stream is obtained by concatenating the fragment data in the order of the file sequence.

Next, playback of a video information signal recorded on the record carrier will be briefly discussed hereafter, with reference to figure 3. Playback of a video information signal recorded on the record carrier is controlled by means of a what is called "playback-

control-program" (PBC program). In general, each PBC program defines a (new) playback sequence. This is a sequence of fragment areas with, for each fragment area, a specification of a data segment that has to be read from that fragment. Reference is made in this respect to figure 3, where playback is shown of only a portion of the first three fragment areas in the sequence of fragment areas in figure 3. A segment may be a complete fragment area, but in general it will be just a part of the fragment area. (The latter usually occurs around the transition from some part of an original recording to the next part of the same or another recording, as a result of editing.)

Note, that simple linear playback of an original recording can be considered as a special case of a PBC program: in this case the playback sequence is defined as the sequence of fragment areas in the real-time file, where each segment is a complete fragment area except, probably, for the segment in the last fragment area of the file. For the fragment areas in a playback sequence, there is no constraint on the location of the fragment areas and, hence, any two consecutive fragment areas may be anywhere in the logical address space.

Next, editing of one or more video information signals recorded on the record carrier will be briefly discussed hereafter, with reference to figure 4. Figure 4 shows two video information signals recorded earlier on the record carrier 3, indicated by two sequences of fragments named "file A" and "file B". For realizing an edited version of one or more video information signals recorded earlier, a new PBC program should be realized for defining the edited AV sequence. This new PBC program thus defines a new AV sequence obtained by concatenating parts from earlier AV recordings in a new order. The parts may be from the same recording or from different recordings. In order to play back a PBC program, data from various parts of (one or more) real-time files has to be delivered to a decoder.This implies a new data stream that is obtained by concatenating parts of the streams represented by each real-time file. In the figure 4, this is illustrated for a PBC program that uses three parts, one from the file A and two from the file B.

Figure 4 shows that the edited version starts at a point P_1 in the fragment area f(i) in the sequence of fragment areas of figure A and continues until point P_2 in the new fragment area f(i+1) of file A. Then reproduction jumps over to the point P_3 in the fragment area f(j) in file B and continues until point P_4 in fragment area f(j+2) in file B. Next reproduction jumps over to the point P_5 in the same file B, which may be a point earlier in the sequence of fragment areas of file B than the point P_3, or a point later in the sequence than the point P_4.

Next, a condition for seamless playback during simultaneous recording will be discussed. In general, seamless playback of PBC programs can only be realized under certain conditions. The most severe condition is required to guarantee seamless playback while simultaneous recording is performed. One simple condition for this purpose will be introduced. It is a constraint on the length of the data segments that occur in the playback sequences, as follows: In order to guarantee seamless simultaneous play of a PBC program, the playback sequence defined by the PBC program shall be such that the segment length in all fragments (except the first and the last fragment area) shall satisfy:

$$2 \text{ MB} \leq \text{segment length} \leq 4 \text{ MB}$$

The use of fragment areas allows one to consider worst-case performance requirements in terms of fragment areas and segments (the signal blocks stored in the fragment ares) only, as will be described hereafter. This is based on the fact that single logical fragments areas, and hence data segments within fragment areas, are guaranteed to be physically contiguous on the disc, even after remapping because of defects. Between fragment areas, however, there is no such guarantee: logically consecutive fragment areas may be arbitrarily far away on the disc. As a result of this, the analysis of performance requirements concentrates on the following:

a. For playback, a data stream is considered that is read from a sequence of segments on the disc. Each segment is contiguous and has an arbitrary length between 2 MB and 4 MB, but the segments have arbitrary locations on the disc.

b. For recording, a data stream is considered that is to be written into a sequence of 4 MB fragment areas on the disc. The fragment areas have arbitrary locations on the disc.

Note that for playback, the segment length is flexible. This corresponds to the segment condition for seamless play during simultaneous record. For record, however, complete fragment areas with fixed length are written.

Given a data stream for record and playback, we will concentrate on the disc subsystem during simultaneous record and playback. It is assumed that the video recorder subsystem delivers data with a peak user rate R to the disc subsystem for recording. Likewise, it accepts data with a peak user rate R from the disc subsystem for playback. It is also assumed that the video recorder subsystem delivers a sequence of segment addresses for both the record and the playback stream well in advance.

For simultaneous recording and playback, the disc subsystem has to be able to interleave read and write actions such that the record and playback channels can guarantee sustained performance at the peak rate without buffer overflow or underflow. In general, different R/W scheduling algorithms may be used to achieve this. There are, however, strong reasons to do scheduling in such a way that the R/W cycle time at peak rates is as short as possible:

- Shorter cycle times imply smaller buffer sizes for the read and write buffer, and hence for the total memory in the disc subsystem.
- Shorter cycle times imply shorter response times to user actions. As an example of response time consider a situation where the user is doing simultaneous recording and playback and suddenly wants to start playback from a new position. In order to keep the overall apparatus response time (visible to the user on his screen) as short as possible, it is important that the disc subsystem is able to start delivering stream data from the new position as soon as possible. Of course, this must be done in such a way that, once delivery has started, seamless playback at peak rate is guaranteed. Also, writing must continue uninterruptedly with guaranteed performance.

For the analysis here, a scheduling approach is assumed, based on a cycle in which one complete fragment area is written. For the analysis of drive parameters below, it is sufficient to consider the minimum cycle time under worst-case conditions. Such a worst-case cycle consists of a writing interval in which a 4 MB segment is written, and a reading interval in which at least 4 MB is read, divided over one or more segments. The cycle includes at least two jumps (to and from the writing location), and possibly more, because the segment lengths for reading are flexible and may be smaller than 4 MB. This may result in additional jumps from one read segment location to another. However, since read segments are no smaller than 2 MB, no more than two additional jumps are needed to collect a total of 4 MB. So, a worst-case R/W cycle has a total of four jumps, as illustrated in figure 5. In this figure, x denotes the last part of a read segment, y denoted a complete read segment, with length between 2 MB and 4 MB, and z denotes the first part of a read segment and the total size of x, y and z is again 4 MB in the present example.

In general, the required drive parameters to achieve a guaranteed performance for simultaneous recording and playback depend on major design decisions such as the rotational mode etc. These decisions in turn depend on the media characteristics.

The above formulated conditions for seamless play during simultaneous record are derived such that they can be met by different designs with realistic parameters. In order to show this, we discuss the example of a CLV (constant linear velocity) drive design here.

In the case of a CLV design, transfer rates for reading and writing are the same and independent of the physical location on the disc. Therefore, the worst-case cycle described above can be analyzed in terms of just two drive parameters: the transfer rate R and the worst-case all-in access time τ. The worst-case access time τ is the maximum time between the end of data transfer on one location and the begin of data transfer on another location, for any pair of locations in the data area of the disc. This time covers speed-up/down of the disc, rotational latency, possible retries etc., but not processing delays etc.

For the worst-case cycle described in the previous section, all jumps may be worst-case jumps of duration τ. This gives the following expression for the worst-case cycle time:

$$T_{max} = 2F/R_t + 4.\tau$$

where F is the fragment size: $F = 4\ MB = 33.6\ .10^6$ bits.

In order to guarantee sustainable performance at peak user rate R, the following should hold:

$$F \geq R.T_{max}$$

This yields:

$$R \leq F/T_{max} = R_t.F/2.(F + 2R_t.\tau)$$

As an example, with $R_t = 35$ Mbps and $\tau = 500$ ms, we would have: $R \leq 8.57$ Mbps.

Next, editing will be further described. Creating a new PBC program or editing an existing PBC program, generally results in a new playback sequence. It is the objective to guarantee that the result is seamlessly playable under all circumstances, even during simultaneous recording. A series of examples will be discussed, where it is assumed that the intention of the user is to make a new AV stream out of one or two existing AV streams. The examples will be discussed in terms of two streams A and B, where the intention of the user is

to make a transition from A to B. This is illustrated in figure 6, where a is the intended exit point from stream A and where b is the intended entry point into stream B.

Figure 6a shows the sequence of fragment areas ......, f(i-1), f(i), f(i+1), f(i+2), ... of the stream A and figure 6b shows the sequence of fragment areas ......, f(j-1), f(j), f(j+1), f(j+2), ... of the stream B. The edited video information signal consists of the portion of the stream A preceding the exit point a in fragment area f(i+1), and the portion of the stream B starting from the entry point b in fragment area f(j).

This is a general case that covers all cut-and-paste-like editing, including appending two streams etc. It also covers the special case where A and B are equal. Depending on the relative position of a and b, this special case corresponds to PBC effects like skipping part of a stream or repeating part of a stream.

The discussion of the examples focuses on achieving seamless playability during simultaneous recording. The condition for seamless playability is the segment length condition on the length of the signal blocks of information stored in the fragment areas, that was discussed earlier. It will be shown below that, if streams A and B satisfy the segment length condition, then a new stream can be defined such that it also satisfies the segment length condition. Thus, seamlessly playable streams can be edited into new seamlessly playable streams. Since original recordings are seamlessly playable by construction, this implies that any edited stream will be seamlessly playable. As a result, arbitrarily editing earlier edited streams is also possible. Therefore streams A and B in the discussion need not be original recordings: they can be arbitrary results of earlier virtual editing steps.

In a first example, a simplified assumption will be made about the AV encoding format and the choice of the exit and entry points. It is assumed that the points a and b are such that, from the AV encoding format point of view, it would be possible to make a straightforward transition. In other words, it is assumed that straightforward concatenation of data from stream A (ending at the exit point a) and data from stream B (starting from entry point b) results in a valid stream, as far as the AV encoding format is concerned.
The above assumption implies that in principle a new playback sequence can be defined based on the existing segments. However, for seamless playability at the transition from A to B, we have to make sure that all segments satisfy the segment length condition. Let us concentrate on stream A and see how to ensure this. Consider the fragment area of stream A that contains the exit point a. Let s be the segment in this fragment area that ends at point a, see figure 6a.

If l(s), the length of s, is at least 2 MB, then we can use this segment in the new playback sequence and point a is the exit point that should be stored in the PBC program.

However, if l(s) is less than 2 MB, then the resulting segment s does not satisfy the segment length condition. This is shown in figure 7. In this case a new fragment area, the so-called bridging fragment area f' is created. In this fragment area, a bridging segment comprising a copy of s preceded by a copy of some preceding data in stream A, is stored. For this, consider the original segment r that preceded s in stream A, shown in figure 7a. Now, depending on the length of r, the segment stored in fragment area f(i), either all or part of r is copied into the new fragment area f:

If $l(r) + l(s) \leq 4$ MB, then all of r is copied into f, and the original segment r is not used in the new playback sequence, as illustrated in figure 7a. More specifically, the new exit point is the point denoted a', and this new exit point a'is stored in the PBC program, and later on, after having terminated the editing step, recorded on the disc like record carrier. Thus, in response to this PBC program, during playback of the edited video information stream, after having read the information stored in the fragment area f(i-1), the program jumps to the bridging fragment area f', for reproducing the information stored in the bridging fragment area f', and next jumps to the entry point in the video stream B to reproduce the portion of the B stream, as schematically shown in figure 7b.

If $l(r) + l(s) > 4$ MB, then some part p from the end of r is copied into f', where the length of p is such that we have

$$2\ \text{MB} \leq l(r) - l(p) \leq 4\ \text{MB} \wedge 2\ \text{MB} \leq l(p) + l(s) \leq 4\ \text{MB}$$

Reference is made to figure 8, where figure 8a shows the original A stream and figure 8b shows the edited stream A with the bridging fragment area f'. In the new playback sequence, only a smaller segment r' in the fragment area f(i) containing r is now used. This new segment r' is a subsegment of r, viz. the first part of r with length $l(r') = l(r) - l(p)$. Further, a new exit point a' is required, indicating the position where the original stream A should be left, for a jump to the bridging fragment f'. This new exit position should therefore be stored in the PBC program, and stored later on on the disc.

In the example given above, it was discussed how to create a bridging segment (or: bridging block of information) for the fragment area f', in case the last segment in stream A (i.e. s) becomes too short. We will now concentrate on stream B. In stream B, there is a similar situation for the segment that contains the entry point b, see figure 9. Figure 9a shows the original stream B and figure 9b shows the edited stream. Let t be the segment comprising the entry point b. If t becomes too short, a bridging segment g can be created for storage in a

corresponding bridging fragment area. Analogous to the situation for the bridging fragment area f', g will consist of a copy of t plus a copy of some more data from stream B. This data is taken from the original segment u that succeeds t in the fragment area f(j+1) in the stream B. Depending on the length of u, either all or a part of u is copied into g. This is analogous to the situation for r described in the earlier example. We will not describe the different cases in detail here, but figure 9b gives the idea by illustrating the analogy of figure 8, where u is split into v and u'. This results in a new entry point b' in the B stream, to be stored in the PBC program and, later on, on the record carrier.

The next example, described with reference to figure 10, shows how a new seamlessly playable sequence can be defined under all circumstances, by creating at most two bridging fragments (f' and g). It can be shown that, in fact, one bridging fragment area is sufficient, even if both s and t are too short. This is achieved if both s and t are copied into a single bridging fragment area (and, if necessary, some preceding data from stream A and/or some succeeding data from stream B). This will not be described extensively here, but figure 10 shows the general result.

In examples described above, it was assumed that concatenation of stream data at the exit and entry points a and b was sufficient to create a valid AV stream. In general, however, some re-encoding has to be done in order to create a valid AV stream. This is usually the case if the exit and entry points are not at GOP boundaries, when the encoded video information signal is an MPEG encoded video information signal. The re-encoding will not be discussed here, but the general result will be that some bridge sequence is needed to go from stream A to stream B. As a consequence, there will be a new exit point a' and a new entry point b', and the bridge sequence will contain re-encoded data that corresponds with the original pictures from a' to a followed by the original pictures from b to b'.
Not all the cases will be described in detail here, but the overall result is like in the previous examples: there will be one or two bridging fragments to cover the transition from A to B. As opposed to the previous examples, the data in the bridging fragments is now a combination of re-encoded data and some data copied from the original segments. Figure 11 gives the general flavour of this.

As a final remark, note that one does not have to put any special constraints on the re-encoded data. The re-encoded stream data simply has to satisfy the same bitrate requirements as the original stream data.

Figure 12 shows a schematic version of the apparatus in more detail. The apparatus comprises a signal processing unit 100 which is incorporated in the subsystem 8 of

figure 1. The signal processing unit 100 receives the video information signal via the input terminal 1 and processes the video information into a channel signal for recording the channel signal on the disc like record carrier 3. Further, a read/write unit 102 is available which is incorporated in the disc subsystem 6. The read/write unit 102 comprises a read/write head 104, which is in the present example an optical read/write head for reading/writing the channel signal on/from the record carrier 3. Further, positioning means 106 are present for positioning the head 104 in a radial direction across the record carrier 3. A read/write amplifier 108 is present in order to amplify the signal to be recorded and amplifying the signal read from the record carrier 3. A motor 110 is available for rotating the record carrier 3 in response to a motor control signal supplied by a motor control signal generator unit 112. A microprocessor 114 is present for controlling all the circuits via control lines 116, 118 and 120.

The signal processing unit 110 is adapted to convert the video information received via the input terminal 1 into blocks of information of the channel signal having a specific size. The size of the blocks of information (which is the segment mentioned earlier) can be variable, but the size is such that it satisfies the following relationship:

$$SFA/2 \leq \text{size of a block of the channel signal} \leq SFA,$$

where SFA equals the fixed size of the fragment areas. In the example given above, SFA = 4 MB. The write unit 102 is adapted to write a block of information of the channel signal in a fragment area on the record carrier.

In order to enable editing of video information recorded in an earlier recording step on the record carrier 3, the apparatus is further provided with an input unit 130 for receiving an exit position in a first video information signal recorded on the record carrier and for receiving an entry position in a second video information signal recorded on that same record carrier. The second information signal may be the same as the first information signal. Further, the apparatus comprises a memory 132, for storing information relating to the said exit and entry positions. Further the apparatus comprises a bridging block generating unit 134, incorporated in the signal processing unit 100, for generating at least one bridging block of information (or bridging segment) of a specific size. As explained above, the bridging block of information comprises information from at least one of the first and second video information signals, which information is located before the exit position in the first video information signal and/or after the entry position in the second video information signal. During editing, as described above, one or more bridging segments are generated in the unit 134 and in the edit

step, the one or more bridging segment(s) is (are) recorded on the record carrier 3 in a corresponding fragment. The size of the at least one bridging block of information also satisfies the relationship:

$$SFA/2 \leq \text{size of a bridging block of information} \leq SFA.$$

Further, the PBC programs obtained in the edit step can be stored in a memory incorporated in the microprocessor 114, or in another memory incorporated in the apparatus. The PBC program created in the edit step for the edited video information signal will be recorded on the record carrier, after the editing step has been terminated. In this way, the edited video information signal can be reproduced by a different reproduction apparatus by retrieving the PBC program from the record carrier and reproducing the edited video information signal using the PBC program corresponding to the edited video information signal.

In this way, an edited version can be obtained, without re-recording portions of the first and/or second video information signal, but simply by generating and recording one or more bridging segments into corresponding (bridging) fragment areas on the record carrier.

A further improvement to the simultaneous recording and playback mode, described above with reference to figure 5, will be described hereafter. It should be noted here, that the improved simultaneous recording and playback method described hereafter can be applied in recording/reproduction apparatuses that need not be equipped with the other features described above.

The read time for reading the portions x, y and z, shown in figure 5, can be further decreased by re-ordering the read steps of the portions x, y and z, into a, b and c, with $\{a,b,c\}=\{x,y,z\}$, such that the time required for reaching and reading the portions x, y and z, inclusive the jump times between the reading steps of reading the portions x, y and z, and inclusive the jump to the position where the next fragment area should be recorded, is minimal. Large jumps in the radial direction of the record carrier in a CLV system requires large speed variations of the rotational speed of the record carrier and thus require a large response time before the record carrier has reached its required rotational speed after a jump. Thus, by minimizing in fact the total time required for the jumps in a complete cycle, the lowest worst-case cycle time T_{max} can be obtained.

The improvement can be realized in the following way, namely if the new order is such that the movement defined by

- jumping from the last fragment area written to the fragment area from which the first portion to be read should be recovered,
- after having read the first portion, jumping to the fragment area from which the next portion to be read should be recovered,
- after having read the second portion, jumping to the fragment area from which the third portion to be read should be recovered,
- after having read the third portion, jumping to the position of the fragment area in which the next portion of the information signal should be recorded,

never crosses any radius more than twice. As a result, the total adjustment of the revolution speed of the record carrier amounts to no more than the equivalent of one speed-up/down sweep.

Figure 13 shows two examples of jumps in a cycle. In figure 13a, after having written a 4 MB fragment, the writing step indicated by w_0 in figure 13a, the system jumps to the position indicated by a, where one of the portions x, y and z, is recorded, for reading the portion. Next, the system jumps to b, the position where the other portion of the portions x, y and z, is recorded, for reading the portion. Next, the system jumps to c, the position where the last of the portions x, y and z is recorded, for reading the portion. Next, the system jumps to the position w_1, indicating the position where the next 4 MB fragment is recorded. Figure 13b shows the same, for a different location of the various positions on the record carrier.

The upper bound for worst-case all-in jump time in total cycle (four jumps):

$$t(w_0 \rightarrow a) + t(a \rightarrow b) + t(b \rightarrow c) + t(c \rightarrow w_1) \leq t_{max4}$$

An example of an upper bound approximation from basic drive parameters: maximum CLV speed (speed up/down) access time 500 ms, and maximum CAV (constant angular velocity) access time 200 ms, results in $t_{max4} \leq 1.4$ s.

Maximum sustainable user rate:

$$R \leq F / T_{max} = R_t.F / 2(F + 2.R_t.\tau).$$

With $\tau = 0.25\ t_{max4} = 350$ ms and $R_t = 35$ Mbps, this results in $R \leq 10.1$ Mbps.

The earlier calculation of the user rate resulted in R ≤ 8.57 Mbps. As shown in the above calculation, based on the same drive parameters, the re-ordering allows for a higher user rate, namely ≤ 10.1 Mbps.

Whilst the invention has been described with reference to preferred embodiments thereof, it is to be understood that these are not limitative examples. Thus, various modifications may become apparent to those skilled in the art, without departing from the scope of the invention, as defined by the claims. In this respect, it should be noted that first generation apparatuses in accordance with the invention, capable of carrying out recording and reproduction of a real time information signal, may be capable of recording signal blocks of fixed size SFA in the fragment areas only, whilst they are already capable of reproducing and processing signal blocks of variable size from the fragment areas in order to reproduce a real time information signal from a record carrier that has signal blocks of variable size stored in the fragment areas. Second generation apparatuses that are moreover capable of carrying out an editing step, will be capable of recording signal blocks of variable size in the fragment areas.

Further, the invention lies in each and every novel feature or combination of features.

CLAIMS:

1. Apparatus for recording a real time information signal, such as a digital video signal, on a disc like record carrier, a data recording portion of which is subdivided into fixed sized fragment areas, the apparatus comprising
- input means for receiving the information signal,
- signal processing means for processing the information signal into a channel signal for recording the channel signal on the disc like record carrier,
- writing means for writing the channel signal on the record carrier,

the signal processing means being adapted to convert the information signal into blocks of information of the channel signal, the writing being adapted to write a block of information of the channel signal in a fragment area on the record carrier, and wherein the signal processing is further adapted to convert the information signal into the blocks of information of the channel signal, such that the size of the blocks of information can be variable and satisfies the following relationship:

$$SFA/2 \leq \text{size of a block of the channel signal} \leq SFA,$$

where SFA equals the fixed size of the fragment area.

2. Apparatus for editing a real time information signal, such as a digital video signal, recorded in an earlier recording step on a disc like record carrier, a data recording portion of which is subdivided into fixed sized fragment areas, the information signal being converted into a channel signal prior to recording and subsequently recorded on the record carrier, such that blocks of information of the channel signal are recorded in corresponding fragment areas on the record carrier, the apparatus comprising:
- input means for receiving an exit position in a first information signal recorded on the record carrier and for receiving an entry position in a second information signal, which may be the first information signal, recorded on the record carrier,
- means for storing information relating to the said exit and entry position,

- bridging block generating means for generating at least one bridging block of information, which bridging block of information comprises information from at least one of the first and second information signals, which information is located before the exit position in the first information signal and/or after the entry position in the second information signal, and where the size of a bridging block of information can be variable and satisfies the requirement:

$$SFA/2 \leq \text{size of a bridging block of information} \leq SFA,$$

where SFA equals the fixed size of the fragment areas,
- writing means for writing the at least one bridging block of information into a corresponding fragment area, and
- means for reproducing the edited stream of information from said record carrier.

3. Apparatus as claimed in claim 1 or 2, where SFA equals 4 MB.

4. Apparatus as claimed in claim 2, wherein, when the amount of information in a first fragment area of the first information signal that comprises the exit position, from the beginning of the block of information in that fragment area to the exit position is smaller than SFA/2, then the bridging block generating means is adapted to generate the bridging block of information from the information in said first fragment area preceding said exit position and at least a final portion of information stored in a second fragment area, directly preceding said first fragment area in the first information signal, such that the requirement to the size of the bridging block of information is met.

5. Apparatus as claimed in claim 4, wherein the remaining information stored in said second fragment area satisfies the requirement: $SFA/2 \leq$ size of remaining portion of information in said second fragment area $\leq SFA$, and that the boundary between said remaining portion of information and the final portion of information in said second fragment area is the new exit position from the first information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprising means for storing information relating to said new exit position.

6. Apparatus as claimed in claim 2, wherein, when the amount of information in a first fragment area of the first information signal that comprises the exit position, from the

beginning of the block of information in that fragment area to the exit position is smaller than SFA/2, then the bridging block generating means is adapted to generate the bridging block of information from the information in said first fragment preceding said exit position and the information stored in a second fragment area, directly preceding said first fragment area in the first information signal.

7. Apparatus as claimed in claim 6, wherein the final position of the signal block in a third fragment area directly preceding said second fragment area in the first information signal is the new exit position from the first information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprising means for storing information relating to the said new exit position.

8. Apparatus as claimed in claim 2, wherein, when the amount of information in a first fragment area of the second information signal that comprises the entry position, from the entry position to the end of the block of information in that fragment area is smaller than SFA/2, then the bridging block generating means is adapted to generate the bridging block of information from the information in said first fragment area following said entry position and at least a start portion of information stored in a second fragment area, directly following said first fragment area in the second information signal, such that the requirement to the size of the bridging block of information is met.

9. Apparatus as claimed in claim 8, wherein the remaining information stored in said second fragment area satisfies the relationship: SFA/2 $\leq$ size of remaining portion of information in said second fragment area $\leq$ SFA, and that the boundary between said remaining portion of information and the start portion of information in said second fragment area is the new entry position into the second information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprising means for storing information relating to said new entry position.

10. Apparatus as claimed in claim 2, wherein, when the amount of information in a first fragment area of the second information signal that comprises the entry position, from the entry position to the end of the block of information in that fragment area is smaller than SFA/2, the bridging block generating means is adapted to generate the bridging block of information from the information in said first fragment area following said entry position and

the information stored in a second fragment area, directly following said first fragment area in the second information signal.

11. Apparatus as claimed in claim 10, wherein the start position of the signal block in a third fragment area directly following said second fragment in said second information signal is the new entry position into the second information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprising means for storing information relating to the said new entry position.

12. Apparatus as claimed in claim 2, wherein, when the amount of information in a first fragment area of the first information signal that comprises the exit position, from the beginning of the block of information in that fragment area to the exit position is smaller than SFA/2, then the bridging block generating means is adapted to generate the bridging block of information from the information in said first fragment area preceding said exit position and at least a portion of the information stored in a second fragment area of the second information signal that comprises the entry position, said portion extending from said entry point in the direction of the end position of said second fragment area, such that the requirement to the size of the bridging block of information is met.

13. Apparatus as claimed in claim 12, wherein the bridging block of information comprises the information in said first fragment area preceding said exit position and only a portion of information of the second fragment area, such that the requirement to the size of the portion of information in the second fragment area following the portion stored in the bridging block is also met.

14. Apparatus as claimed in claim 12 or 13, wherein the end position of the signal block included in a third fragment area directly preceding the first fragment area in the first information signal is the new exit position from the first information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprises means for storing said new exit position.

15. Apparatus as claimed in claim 12, wherein the start position of the signal block included in a fourth fragment area directly following the second fragment area in the second information signal is the new entry position into the second information signal, when

reproducing the edited stream of information by said apparatus, the apparatus further comprises means for storing said new entry position.

16. Apparatus as claimed in claim 13, wherein the start position of the portion of information in said second fragment area that follows the portion stored in said bridging block is the new entry position into the second information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprises means for storing said new entry position

17. Apparatus as claimed in claim 2, wherein, when the amount of information in a first fragment of the second information signal that comprises the entry position, from the entry position to the end of the block of information in that fragment area is smaller than SFA/2, then the bridging block generating means is adapted to generate the bridging block of information from the information in said first fragment area following said entry position and at least a portion of the information stored in a second fragment of the first information signal that comprises the exit position, said portion extending from said exit point in the direction of the start position of said signal block in said second fragment area, such that the requirement to the size of the bridging block of information is met.

18. Apparatus as claimed in claim 17, wherein the bridging block of information comprises the information in said first fragment area following said entry position and only a portion of information of the second fragment area, such that the requirement to the size of the portion of information in the second fragment area preceding the portion stored in the bridging block is also met.

19. Apparatus as claimed in claim 17 or 18, wherein the start position of the signal block included in a third fragment area directly following the first fragment area in the second information signal is the new entry position into the second information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprises means for storing said new entry position.

20. Apparatus as claimed in claim 17, wherein the end position of the signal block included in a fourth fragment area directly preceding the second fragment area in the first information signal is the new exit position from the first information signal, when reproducing

the edited stream of information by said apparatus, the apparatus further comprises means for storing said new exit position.

21. Apparatus as claimed in claim 18, wherein the end position of the portion of information in said second fragment area that precedes the portion stored in said bridging block is the new exit position from the first information signal, when reproducing the edited stream of information by said apparatus, the apparatus further comprises means for storing said new exit position

22. Apparatus as claimed in claim 2, wherein the apparatus further comprises
- means for decoding a portion of the information in the first information signal before the exit point, for decoding a portion of the information in the second information signal after the entry point,
- means for generating a composite signal derived from said decoded portions of the first and the second information signals,
- means for encoding the composite signal,
- means for accommodating the encoded composite signal in one or more bridging blocks of informationfragments, the size of the bridging blocks of information comprising the encoded composite signal can be variable and satisfies the requirement:

$$SFA/2 \leq \text{size of a block of information of the encoded composite signal} \leq SFA.$$

and means for writing the bridging blocks of information comprising the encoded composite signal into corresponding fragment areas.

23. Method of recording a real time information signal, such as a digital video signal, on a disc like record carrier in an apparatus as claimed in claim 1.

24. Method of editing a real time information signal recorded in an earlier recording step on a disc like record carrier, in an apparatus as claimed in anyone of the claims 2 to 22.

25. Disc like record carrier obtained with the method as claimed in claim 23 or 24.

26. Disc like record carrier having a real time information signal recorded on it, the record carrier having a data recording portion which is subdivided into fixed sized fragment areas, the information signal being recorded on the record carrier in channel encoded form, the information signal being divided into blocks of information of the channel signal, the blocks of information of the channel signal being written in said fragment areas, the size of the blocks of information stored in a corresponding fragment being variable and satisfying the following requirement:

$$SFA/2 \leq \text{size of a block of information of the channel signal} \leq SFA,$$

where SFA equals the fixed size of the fragment areas.

27. Apparatus for simultaneously recording and reproducing real time information signals, such as digital video signals, on/from a disc like record carrier, a data recording portion of which is subdivided into fixed sized fragment areas, the apparatus comprising
- input means for receiving a first information signal for recording,
- signal processing means for processing the first information signal into a channel signal for recording the channel signal on the disc like record carrier,
- writing means for writing the channel signal on the record carrier,

the signal processing means being adapted to convert the first information signal into blocks of information of the channel, the writing means being adapted to write a block of information of the channel signal in a fragment area on the record carrier,
the apparatus further comprising:
- reading means for reading blocks of information from corresponding fragment areas on the record carrier,
- signal processing means for processing the blocks of information so as to obtain a second information signal,
- output means for supplying the second information signal reproduced from the record carrier,

the simultaneous recording/reproduction of the first and second information signals being carried out in subsequent cycles, a cycle comprising a write step for writing a signal block of the first information signal into a fragment area on the record carrier and a plurality of read steps for reading a portion of information of the second information signal from the same plurality of fragment areas,
the apparatus being adapted to order the reading of the portions in a cycle.

28. Apparatus as claimed in claim 27, the apparatus being adapted to order the reading of the portions in the cycles, such that the total jump time for localizing the fragments in a cycle is minimal.

29. Apparatus for reading a real time information signal, such as a digital video signal, from a disc like record carrier, the information signal being recorded in channel encoded form in a data recording portion of the record carrier, the data recording portion being subdivided into fixed size fragment area, blocks of information of the channel encoded information signal being recorded in corresponding fragment areas, the size of the blocks of information can be variable and satisfy the following relationship:

$$SFA/2 \leq \text{size of a block of information of the channel signal} \leq SFA,$$

where SFA equals the fixed size of the fragment areas,
the apparatus comprising:
- means for reading the channel signal from the record carrier,
- signal processing means for processing the blocks of information of variable size and read from the fragment areas into portions of the information signal,
- means for outputting the information signal.

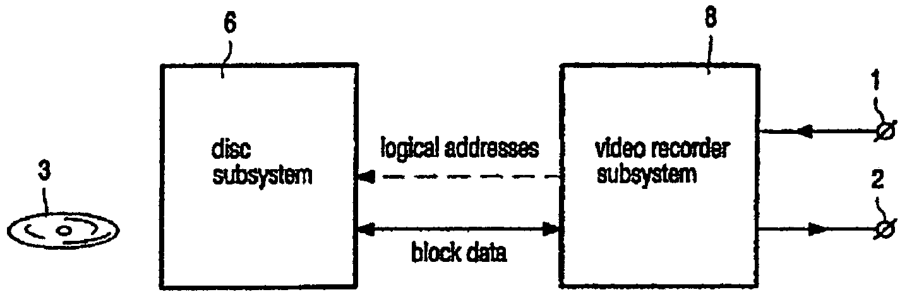

FIG. 1

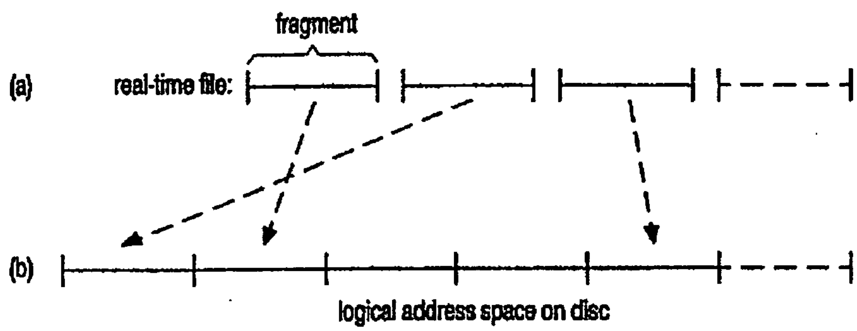

FIG. 2

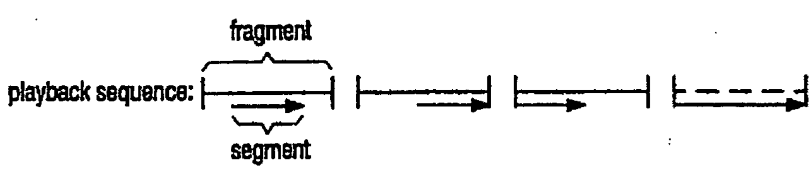

FIG. 3

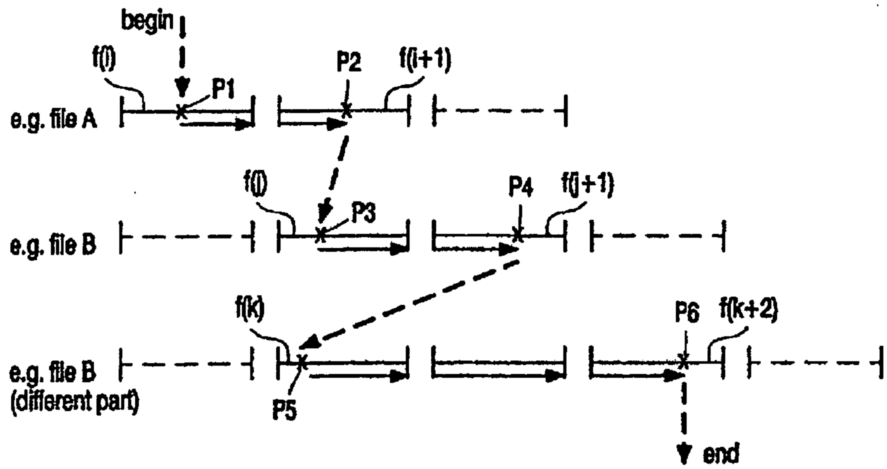
begin
f(i)
P1
P2
f(i+1)
e.g. file A
f(j)
P3
P4
f(j+1)
e.g. file B
f(k)
P6
f(k+2)
e.g. file B
(different part)
P5
end

FIG. 4

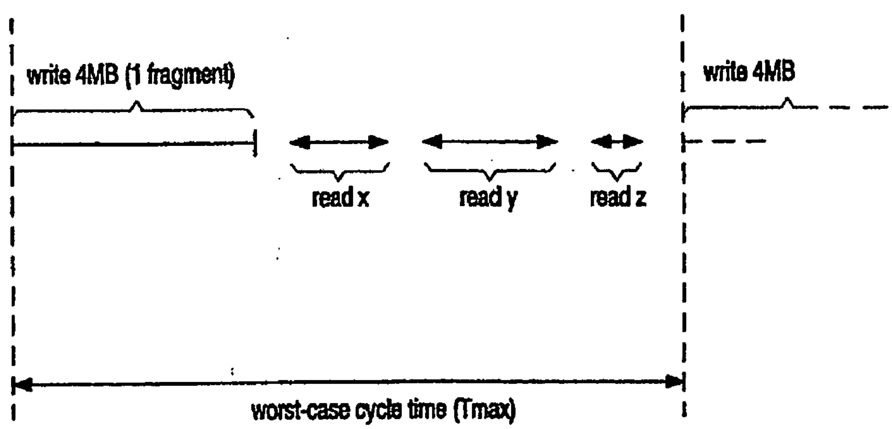
write 4MB (1 fragment)
write 4MB
read x
read y
read z
worst-case cycle time (Tmax)

FIG. 5

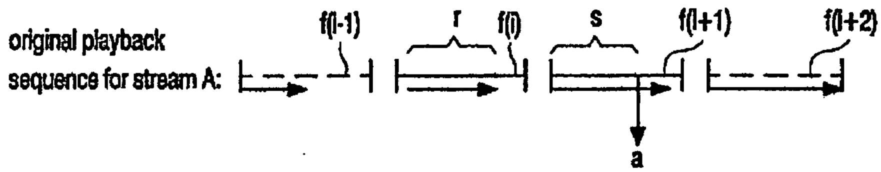

FIG. 6a

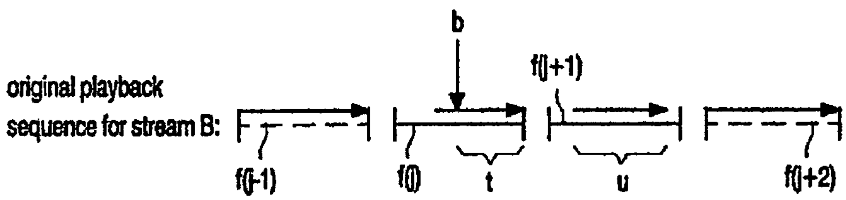

FIG. 6b

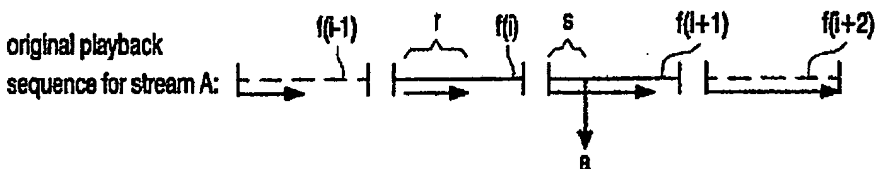

FIG. 7a

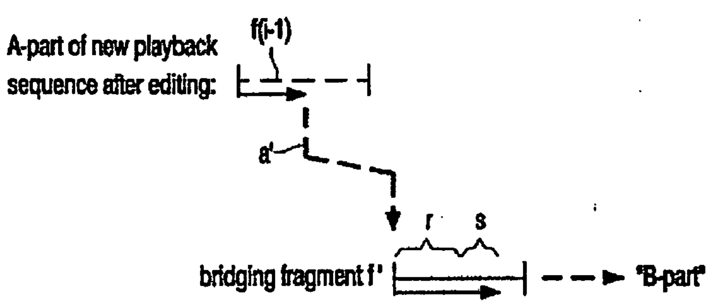

FIG. 7b

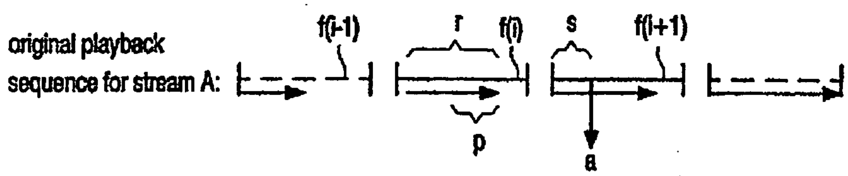

FIG. 8a

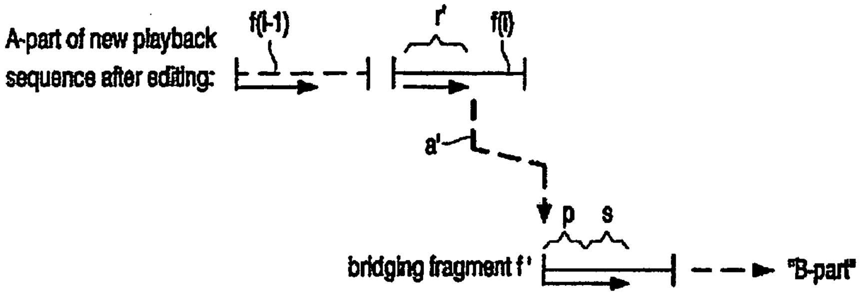

FIG. 8b

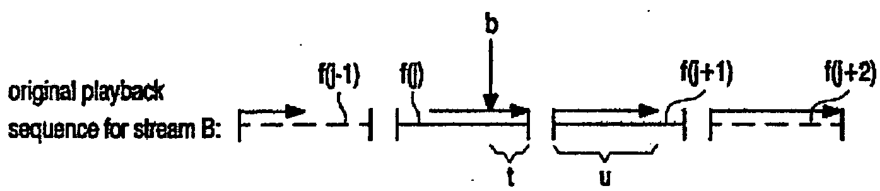

FIG. 9a

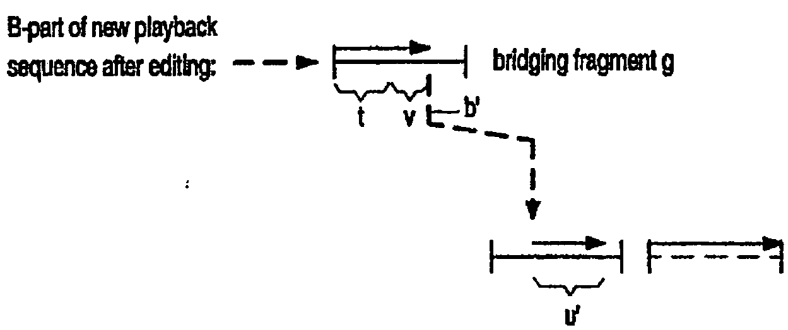

FIG. 9b

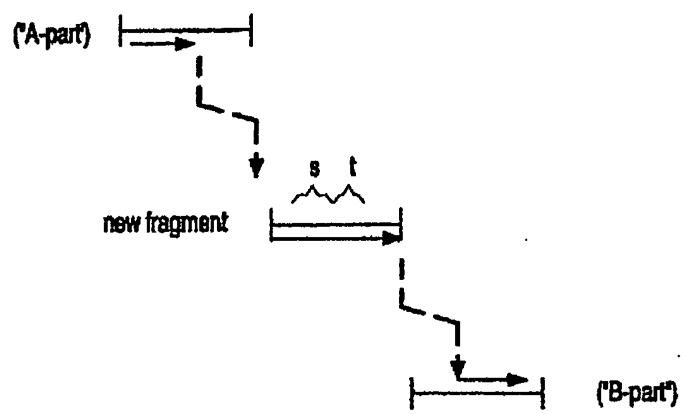
("A-part")
s
t
new fragment
("B-part")

FIG. 10

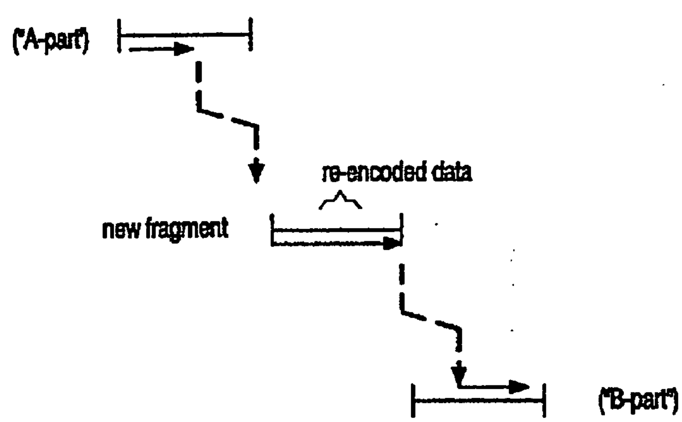
("A-part")
re-encoded data
new fragment
("B-part")

FIG. 11

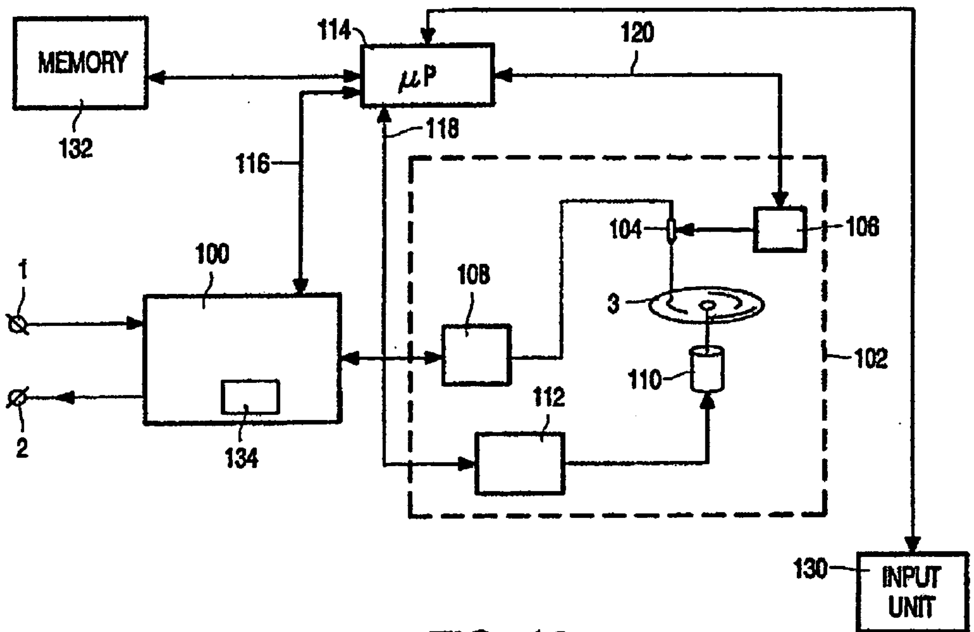

FIG. 12

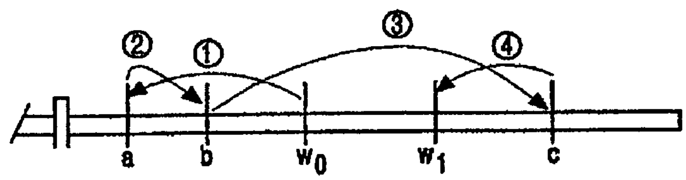

FIG. 13a

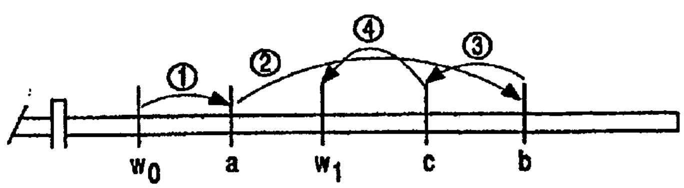

FIG. 13b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/00343

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 20/12, G11B 27/034
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G11B, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EDOC, WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9731374 A1 (TIME WARNER ENTERTAINMENT CO., L.P.), 28 August 1997 (28.08.97), page 16, line 2 - page 26, line 25, figures 7,8,10 --	1-30
P,A	EP 0847198 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 10 June 1998 (10.06.98), see whole document --	1-30
A	EP 0676757 A2 (KABUSHIKI KAISHA TOSHIBA), 11 October 1995 (11.10.95), see whole document -- --------	1-30

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 1999	20 -10- 1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bo Gustavsson/MN Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/IB 99/00343

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9731374 A1	28/08/97	AU 690871 B	30/04/98
		AU 2261997 A	10/09/97
		CA 2218657 A	28/08/97
		EP 0823114 A	11/02/98
		JP 10509548 T	14/09/98
		US 5644507 A	01/07/97
EP 0847198 A1	10/06/98	DE 69602273 D	00/00/00
		CN 1197572 A	28/10/98
		EP 0918438 A	26/05/99
		US 5784528 A	21/07/98
		WO 9713365 A	10/04/97
EP 0676757 A2	11/10/95	JP 7282542 A	27/10/95

Form PCT/ISA/210 (patent family annex) (July 1992)